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Scientific Note

LEAF AGE PREFERENCE FOR OVIPOSITION BY THE MONOPHAGOUS WHITEFLY, *ALEUROTITHIUS TIMBERLAKEI* (HOMOPTERA: ALEYRODIDAE)

Virtually all studies of whitefly-host plant interactions have utilized polyphagous species of whitefly (Homoptera: Aleyrodidae), primarily because the major economic pests in the family Aleyrodidae are polyphagous species. Although this focus on polyphagous species is understandable from an economic perspective, it may provide a very skewed perspective of the family Aleyrodidae from an evolutionary viewpoint because the majority of whitefly species appear to be monophagous or oligophagous (Mound & Halsey 1978. Whitefly of the world, Wiley & Sons, New York). Of the approximately 1000 named species that have host plant records listed in Mound & Halsey's (1978) catalogue, approximately 70% have been recorded from only a single plant family and approximately 62% have been recorded from only a single plant genus.

Determination of a whitefly's leaf age preference for oviposition is an important step in understanding its host selection. Immature whiteflies are sessile except for the early first instar "crawler stage." However, even though whitefly crawlers are mobile, their mobility is very limited and they rarely disperse from the leaf on which they hatched (Lloyd 1922. Ann. Appl. Biol., 9: 1–32, Dowell et al. 1978. J. New York Entomol. Soc., 86: 121–122, Mound & Halsey 1978). Thus, the ovipositing female not only determines the host plant individual that her offspring will have to contend with, but she also determines the particular leaf on which her offspring will be forced to live (or die). The age of the leaf on which immature whiteflies occur can be a critical factor in their survival. For example, survival of newly hatched crawlers of bayberry whitefly, *Parabemisia myricae* (Kuwana) was 49% on young leaves in contrast to 0% on mature leaves of lemon, *Citrus limon* (L.) (Walker & Aitken 1985. Environ. Entomol., 14: 254–257). Consequently, a female whitefly's choice of leaf age for oviposition can have a profound effect on her fitness.

Leaf age selection for oviposition by whiteflies has been noted for only a few species (*Aleurocanthus woglumi* Ashby, *Aleurothrixus floccosus* [Maskell], *Aleurotrachelus jelinekii* [Frauenfeld], *Bemisia argentifolii* Bellows & Perring, *Bemisia tabaci* [Gennadius], *Dialeurodes citri* [Ashmead], *Parabemisia myricae* [Kuwana], *Trialeurodes rara* Singh, and *Trialeurodes vaporariorum* [Westwood]), and all but *A. jelinekii* are very polyphagous (Hargreaves 1915. Ann. Appl. Biol., 1: 303–334, Husain & Trehan 1933. Indian J. Agric. Sci., 3: 701–753, Avidov 1956. Ktavim, 7: 25–41, Khalifa & El-Khidir 1964. Bull. Soc. Entomol. Egypte, 48: 115–129, Mound 1965. Empire Cotton Growing Review, 42: 33–40, Gameel 1974. Rev. Zool. Afr., 88: 784–788, Southwood & Reader 1976. J. Anim. Ecol., 45: 313–325, Yamada et al. 1979. Bull. Veg. & Ornamental Crop Res. Sta. Series A, 5: 191–199, Ohnesorge et al. 1980. Z. Ang. Entomol., 90: 226–232, Swirski et al. 1980. Alon Ha-notea, 34: 627–635, Xu et al. 1984. Z. Ang. Entomol., 97: 305–313, Walker & Aitken 1985. Environ. Entomol., 14: 254–

257, Noldus et al. 1985. Z. Ang. Entomol., 100: 494–503, Noldus et al. 1986. J. Appl. Entomol., 101: 492–507, Southwood et al. 1989. J. Anim. Ecol., 58: 921–942, Dowell 1990. Pan-Pacif. Entomol., 66: 212–216, Walker & Zareh 1990. Entomol. Exp. appl., 56: 31–45, Tonhasca et al. 1994. Environ. Entomol., 23: 949–954). In the present study, the leaf age preference for oviposition by the monophagous whitefly, *Aleurotithius timberlakei* Quaintance & Baker was examined. The known geographic range of *A. timberlakei* is restricted to California (USA), and it is known to occur only on plants in the genus *Eriodictyon* (Hydrophyllaceae) (Mound & Halsey 1978).

The site of this study was an area of natural vegetation adjacent to California Highway 243, about 1.7 km N (following the highway) of the Poppet Flats road junction. The plants used were *E. crassifolium* Bentham that were occurring naturally and in abundance at the study site. Feral *A. timberlakei* adults collected from the study site were used in the tests. Adult whiteflies that were alighted on the foliage were collected by capturing them in transparent drinking straws (5 mm inside diameter, ca. 3.5–5 cm long) which were then sealed with corks at both ends. One whitefly was captured per straw. Whiteflies were collected in this manner from both young and old leaves. This collection method is much gentler than aspiration where the whiteflies collide at great speed with the sides of the aspirator vial.

Within 2 h of capturing the whitefly adults in drinking straws, the whiteflies were placed in preference test cages (one whitefly per cage) that provided them access to the abaxial surface of a young and an old *E. crassifolium* leaf. Leaves were classified as young if they were on new apical or lateral shoots that were clearly separated by a distinct node from the older stem from which they arose. The new shoots were easy to distinguish from the older stems because they were densely hirsute, whereas the older stems were not. The new shoots were obviously recent growth, as they had at their apex either an actively growing apical meristem, or very young unexpanded leaves, or a new flower cluster. Leaves on the older stems were classified as old leaves. Young leaves were softer and more pliable than old leaves. At the time of year that the tests were conducted (late May–mid June), the distinction between young and old leaves at this site was obvious. The preference test cages were transparent plastic cylinders (12 mm inside diameter, 12.5 mm length) that were secured between two leaves (one young and one old), with the abaxial surface of one leaf covering one of the open ends of the cylinder and the abaxial surface of the other leaf covering the other open end of the cylinder. Thus, whiteflies placed in a cage had access to the abaxial surface of either leaf. The test cage was held between the two leaves using a hair clip, and a foam plastic gasket at each end of the cylinder made the seal between the leaf surfaces and the open ends of the cylinder escape-proof. An illustration and a more detailed description of the preference test cages were given by Walker & Zareh (1990). The two leaves that were connected together by a preference test cage were left intact on the plant and were positioned so that the plane of each leaf was vertical (i.e., neither leaf was "above" or "below" the other, thus minimizing geotactic or phototactic cues that the whiteflies might use in selecting one leaf over the other).

A single whitefly adult was placed in each preference test cage by removing the corks from both ends of the drinking straw in which the whitefly was origi-

Table 1. Numbers of eggs present on young and old *E. crassifolium* leaves in areas enclosed by the preference test cages.

		Paired t-test			Fisher's distribution-free test	
Leaf age	Mean number of eggs ± S.E.	N	t	Prob.	wins[a] (young > old)	Prob.[b]
Young	21.05 ± 3.40	37	6.10	<0.0001	35/36	<0.0002
Old	0.35 ± 0.12	37				

[a] The ratio in the column "wins" is the number of replicates where more eggs were laid on the young leaf than on the old leaf over the total number of replicates (excluding one replicate where an equal number of eggs was laid on each leaf) (Hollander & Wolfe 1973).

[b] Two-tailed probability.

nally captured, placing one end of the straw in the cage's entry hole (see Walker & Zareh 1990), and gently blowing through the other end of the straw until the whitefly entered the cage. The entry hole of the cage then was sealed with a cork.

Preference tests were set up in this manner on three dates, 31 May, 7 Jun, and 13 Jun, 1991. Over five different individual *E. crassifolium* plants were used in the tests. Six to seven days after the preference tests were set up in the field, the test leaves were excised from the plants and were brought back to the laboratory for examination with a stereomicroscope. The numbers of whitefly eggs present within the area enclosed by the preference test cage on each leaf was recorded.

For the purpose of statistical analysis, the young and old leaf connected by the same preference test cage were considered a pair. The number of eggs present on the examined areas of the young and old leaves were compared using a paired *t*-test and the conservative non-parametric Fisher Distribution-Free Sign Test (Hollander & Wolfe 1973. Nonparametric statistical methods, Wiley & Sons, New York). The Fisher test compares the observed proportion of replicates where more eggs were laid on the young versus the old leaf to the expected proportion of replicates where more eggs were laid on the young leaf if neither leaf age was preferred (i.e., 0.50). Pairs of leaves where no eggs were laid on either leaf were excluded prior to analysis.

The results from the three dates were similar; therefore, the data were pooled over all dates. The results clearly indicate that *A. timberlakei* has a very strong oviposition preference for young leaves over old leaves of *E. crassifolium* (Table 1). Over 98% of the eggs were laid on the young leaves. The preference for young leaves occurred regardless of whether the adults in the tests were collected from young or old leaves.

A review of the literature (cited earlier) on leave age preference for whitefly oviposition indicates that all of the other whitefly species that have been studied (all but one of which are very polyphagous with ≥14 host plant families recorded by Mound & Halsey 1978) generally prefer the younger leaves of their host plants, although this preference can be influenced by the age of the plant, the season, or other factors (Husain & Trehan 1933, Mound 1965, Ohnesorge et al. 1980). In some cases, the very young, unexpanded leaves are less preferred than slightly older, but still young, fully expanded leaves, although in these cases, the young, fully expanded leaves still are preferred over fully expanded mature leaves (Dowell 1990, Walker & Zareh 1990). Nonetheless, by preferring young leaves, the

monophagous *A. timberlakei* has a leaf age preference similar to those of its polyphagous counterparts.

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